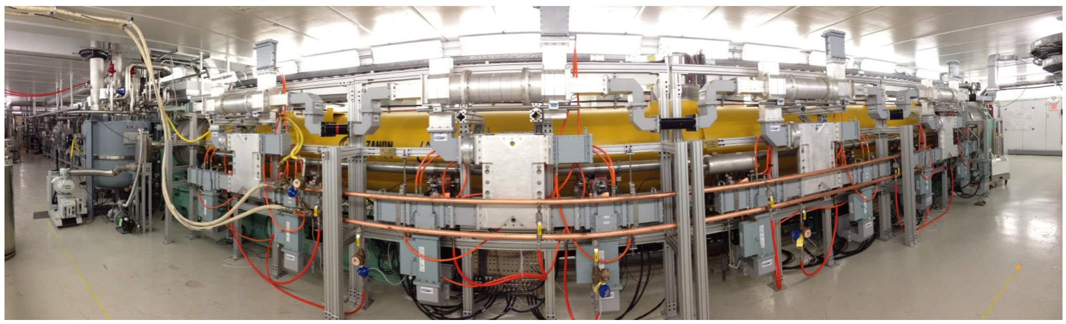
Volume 2, Issue 2 December 2014

Fermilab's ASTA/IOTA Accelerator R&D Facility

ASTA/IOTA Newsletter

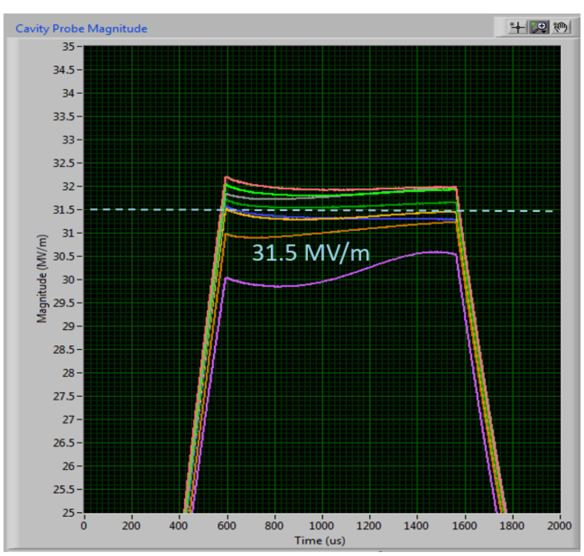
ASTA Electron Injector: ILC-type Cryomodule Makes the Grade



SRF Crymodule 2 (CM2) with RF distribution system

For the first time, the gradient specification of the International Linear Collider (ILC) design study of 31.5 MV/m has been achieved on average across an entire ILC-type cryomodule made of ILC-grade cavities. A team at Fermilab reached the milestone in early October 2014. The cryomodule, called CM2, was developed to advance superconducting radio-frequency technology and infrastructure at laboratories in the Americas region, and was assembled and installed at Fermilab after initial vertical testing of the cavities at Jefferson Lab. The milestone – an achievement for scientists at Fermilab, Jefferson Lab, and their domestic and international partners in superconducting radio-frequency (SRF) technologies – has been nearly a decade in the making, beginning when US scientists started participating in ILC research and development in 2006. Between 2008 and 2010, all eight cavities in CM2, after being electro-polished, had been individually pushed to gradients above 35 MV/m at Jefferson Lab in vertical tests. They were subjected to additional horizontal tests at Fermilab. These eight cavities were among 60 being evaluated globally for the prospect of reaching the ILC gradient. This evaluation was known as the S0 Global Design Effort, and was a build-up to the S1-Global Experiment, which put to the test the possibility of reaching 31.5 MV/m across an entire cryomodule. The final assembly of the S1 cryomodule set-up took place at KEK in Japan between 2010 and 2011. In S1, seven nine-cell 1.3 GHz niobium cavities strung together inside a cryomodule achieved an average gradient of 26 MV/m. An ILC-type cryomodule consists of eight such cavities.

Over the years, teams in the Americas region have acquired significant expertise in SRF technology, including increasing cavity gradients. Cavities manufactured by companies in the US, for example, have improved in quality: three of the eight cavities that make up CM2 were fabricated locally. The CM2 group at Fermilab will push the gradients higher to determine the limits of the technology and to continue to understand and advance it. They expect to send an actual electron beam through CM2 in 2015, to better understand how the beam and cryomodule respond together. The aim is to use CM2 in the Advanced Superconducting Test Accelerator currently being commissioned at Fermilab. The SRF technology developed for FLASH at DESY, the European XFEL and now CM2 also have applications for the proposed PIP-II at Fermilab and at light sources such as LCLS-II at SLAC. (see also *CERN Courier*, December 2014 - http://cerncourier.com/cws/article/cern/59319)



CM2 individual cavity RF gradients

ASTA/IOTA Users Meeting

The 2nd ASTA/IOTA Users Meeting was held at Fermilab on June 9-10, 2014 . There were 56 participants, including 30 from US universities, SBIR companies and National Laboratories other than Fermilab. 25 presentations were made during five sessions: facility status, IOTA, SRF, e-beam, experiments. Many facility's "firsts" were reported, including attainment of the beam macropulse with full 3.2 nC bunch charge from the 5 MeV photoinjector and the ILC-grade 31.5 MV/m accelerating gradient in the individual SRF CM2 cavities (see front page).

This year, many presentations were given by the IOTA collaboration, which includes universities of Chicago and Colorado, as well as UMD, MIT, ORNL, JINR, Radiasoft, Fermilab and TechX— see the agenda and all the talks at ***asta.fnal.gov*** (look for link to "The 2nd Users Meeting")

Sculpted Electron Beams at ASTA by Laser Shaping

Photocathodes are light bulbs in reverse: they collect light and convert it to electrons. The generated electrons surf along a radio-frequency wave to reach relativistic energies ~5 MeV after which they exit the photoinjector and enter the accelerator. The quality of the electron beam entering the accelerator is fixed at birth. Once inside the accelerator, the transport system threatens to adversely affect the beam quality, so it is critical to isolate the cause of any adverse effects and understand them systematically. For example, one such cause is how density modulations on the e-beam evolve inside an accelerator and affect the beams quality. In order to answer this question, Brian Beaudoin (University of Maryland, funded by a grant from URA) along with Fermilab's ASTA injector team members Jayakar 'Charles' Thangaraj, Dean 'Chip' Edstrom, Jinhao Ruan, and Alex Lumpkin are working to deliberately make a "brazen" beam – a beam with a significant density modulation. Such controlled experiments exaggerate the effect that is going on at smaller time and length scales but clarifies the effect of space-charge.

Previous experimental studies were unable to study how such modulations on a space-charge dominated beam behave under acceleration. On Nov 2014, the team was able to generate a shaped electron beam by shaping the laser impinging on the photocathode and sub-sequentially accelerated the shaped electron beam within the L-band (1.3GHz) gun cavity. They used special crystals that have the property of double refraction to shape the laser. Once the ASTA injector is commissioned with a 20 MeV beam, the researchers will look at how acceleration further affects the modulated beam. The ASTA injector facility with its ultra-stable beams, high-resolution diagnostics in electron beams, picosecond lasers, and MHz-repetition rate makes it a unique facility to carry out such beam experiments.

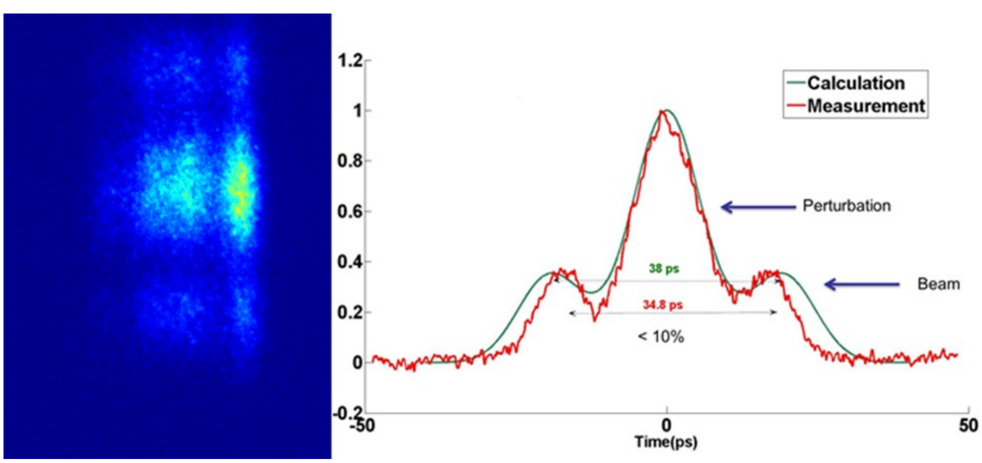


Figure on the left reveals the time profile of the laser pulse with a longitudinal hotspot. Time is on the vertical axis. Figure on the right compares the normalized experimental laser beam time profile (red) with the theory (green).

Prof. Swapan Chattopadhyay joins NIU, Fermilab and ASTA/IOTA

Prof. Swapan Chattopadhyay

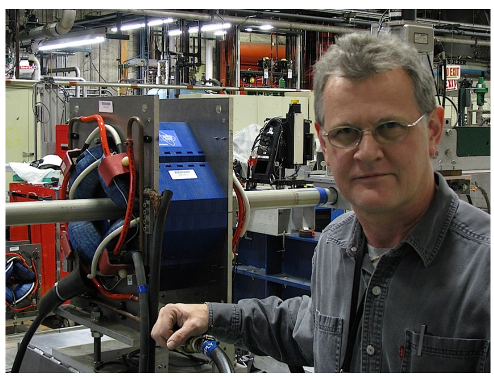
Prof. Swapan Chattopadhyay is a particle accelerator physicist noted for his pioneering contributions of innovative concepts, techniques and developments in high energy particle colliders, phase space cooling techniques, synchrotron radiation sources, free electron lasers, ultrafast sciences, superconducting linear accelerators and various applications of interaction of particle and light beams. He has directly contributed to the development of many accelerators around the world, e.g. the Super Proton - Antiproton Synchrotron collider and the Large Hadron Collider at CERN, the Advanced Light Source at Berkeley, the asymmetric-energy electron-positron collider PEP-II at Stanford, the Continuous Electron Beam Accelerator facility (CEBAF) at Jefferson Lab and the Free-Electron Lasers at Jefferson and Daresbury Laboratories. He was the Founder/Director of Center for Beam Physics at Berkeley (1992-2001); the Associate Laboratory Director for Accelerators at Jefferson Lab (2001-2007) and Sir John Cockcroft Professor of Physics and Inaugural Director of the Cockcroft Institute, UK (2007-2014). Since September 1, 2014 Swapan has joined the Fermilab senior leadership in a joint appointment with Northern Illinois University where he is a professor and director of accelerator science.

"Fermilab is unique in advanced accelerator research and development effort in its critical focus on techniques and technologies for high intensity relativistic beams", says Prof. Chattopadhyay, "Such beams will be crucial to advance our understanding of the 'neutrino' sector of particle physics. To this purpose, I would like to join my colleagues at Fermilab to contribute to advancing innovative nonlinear dynamic techniques for space-charge dominated beams such as could be tested in the planned novel Integrable Optics Test Accelerator (IOTA). This research could lead to the development of a "smart" rapid-cycling high-intensity booster synchrotron as part of a future neutrino facility. In addition, the precise electron beam produced by ASTA as the 150-300 MeV superconducting linear accelerator injector to IOTA by itself offers many novel experimental possibilities for advanced accelerator research such as ultra-cold electron beams and ultrafast electron-light interactions."

IOTA Ring Quads

The IOTA team has completed refurbishment of 32 quadrupole magnets for the Integrable Optics Test Accelerator ring (IOTA), provided as an in-kind contribution by JINR (Russia). Fermilab's Technical Division is measuring the magnets' field quality, excitation.

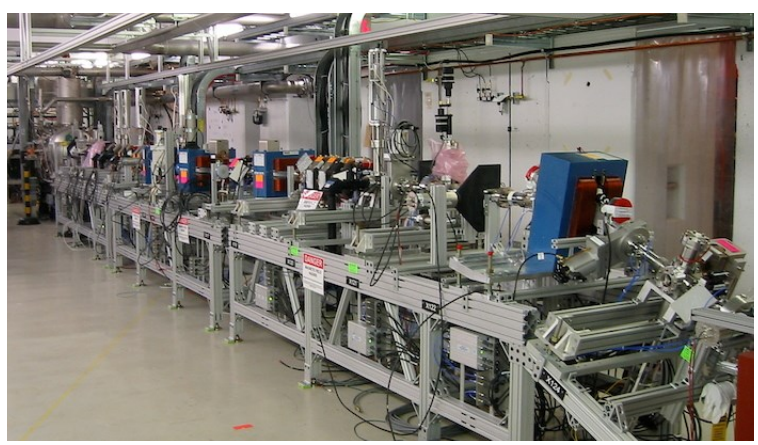
On the right: TD's Mark Thompson performs rotating coil measurements of an IOTA quadrupole.



ASTA/IOTA Plans for 2015

The ASTA/IOTA team has recently re-assessed the facility's technical plans for 2015 based on the 2014 results and available resources. Our expectations are:

1. Build and commission low energy 25-50 MeV injector and deliver electron beam to the low energy beam absorber (Q2 FY15);
2. Carry out high gradient studies of the SRF CM2 for total of 6 months in Q1-Q3 FY15;
3. Installation of >50% of the high-energy 300MeV beamline and accelerator cave extension in FY15;
4. Continue construction and installation of the IOTA ring to ~ 2/3 completion by the end of FY15.



Low energy (25-50 MeV) beam line at ASTA ready for the first electrons.

ASTA
Fermilab, PO Box 500, MS221
Accelerator Physics Center
Batavia, IL 60510
Phone: 630-840-5241
Fax: 630-840-6039
E-mail: shiltsev@fnal.gov

We are on the Web !
asta.fnal.gov

The ASTA/IOTA facility currently under construction and commissioning at Fermilab will enable a broad range of beam-based experiments to study fundamental limitations to beam intensity and to develop transformative approaches to particle-beam generation, acceleration and manipulation. The centerpiece of ASTA is the Integrable Optics Test Accelerator (IOTA) - a small-circumference ring capable of storing electrons or protons—and its electron and proton injector accelerators.

ASTA is a unique resource for R&D towards Intensity and Energy Frontier facilities. It also offers a test-bed for SRF accelerators and high-brightness beam applications.

Questions, inquiries? Please visit our Web site http://asta.fnal.gov or contact Vladimir Shiltsev, ASTA/IOTA Director (Interim) at shiltsev@fnal.gov

Accolades

Sandra Biedron Elected Senior Member of Optical Society of America.

Congratulations to Professor Sandra Biedron - one of ASTA/IOTA's most active collaborators - with her election to Senior Member of the Optical Society of America!

Dr. Sandra G. Biedron is an Associate Professor of Electrical and Computer Engineering at Colorado State University. Formerly she was the Department of Defense project office director and a physicist at Argonne National Laboratory and was an associate director of the Argonne Accelerator Institute. Sandra served as a consultant on the successful FERMI project at Sincrotone Trieste. She was one of the team members at Argonne who proved the SASE FEL concept in the visible to VUV wavelengths. Sandra was also the Argonne representative and participant on the Brookhaven/Argonne high-gain harmonic generation FEL experiment. At ASTA/IOTA, Sandra and her students pursue research on neural networking approaches to the RF gun water cooling and cavity control and on major beam physics issues with high-intensity electron beams for various applications. Sandra also is an elected member of the Fermilab Users Executive Committee (UEC) and is chairing the Government Relations Committee for the Fermilab UEC. She is a Senior Member of the OSA, a Senior Member of the IEEE, a Fellow of the SPIE, and a Fellow of the American Physical Society.

Prof. Sandra Biedron (far right) and her Colorado State University group